International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-5, Issue-2, June 2016

Suitability of Biomedical Waste Ash in Concrete

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Abstract— **Biomedical waste management is a major problem in India. Waste generated from medical activities is a real problem for living nature and human world. In order to minimize its hazardous effect into the environment some studies confirmed the successful utilisation of biomedical using biomedical waste ash as partial replacement of cement. This paper presents result of an experiment program carried out to study the suitability of use of biomedical waste ash in concrete as partial replacement of cement**.

Index Terms—**Biomedical waste, cement, environment, utilisation.**

I. INTRODUCTION

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Biomedical waste, generated from medical sources and activities is a cause of concern for environmentalist. These wastes are generated in the process of diagnosis treatment and similar activities pertaining to human and animals. Also in the production or testing of biological instruments/components. Biological waste is broadly classified as biological and non biological wastes that may or may not be infectious. According to ministry of environment and forest about 4,05,702 kg biomedical waste generated everyday in India out of which around 72% is disposed off. However more than 28% is biomedical waste is left unattended. Most common process of disposal of biomedical waste is incineration in specifically made for biomedical waste. Ash obtained after incineration of biomedical waste are used as landfill. However these wastes can effectively been used in concrete making which will result in reduce the demand of land for disposal of biomedical waste ash on one hand and protection of environment by reducing the consumption and production of cement on other hand.

Toxicity and potential hazards of biomedical waste is generally depend upon its origin. It contains heavy toxic metals which are very harmful for human body. At present 170 common biomedical waste treatment facilities are available having 140 incinerators throughout the country. Biomedical waste can be used in concrete with replacement by weight for cement. The addition of hospital waste ash in cement matrices can be used as construction material. It can also be used as a stabilising agent in road and asphalt pavements.

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II. REVIEW OF LITEREATURE

Aubert *et al.,* (2004) studied the use of biomedical waste ash on the compressive strength and the durability of hardened concrete and suggest the use of waste in concrete constitutes a potential means of adding value. Al-Mutairi *et al.,* (2004) compared the compressive strength of mixtures made with bottom and fly hospital ash in order to evaluate the effectiveness of reusing hospital incinerator ash. Results showed that when 5% microsilica and fly ash were incorporated, the compressive strength of cubes was further increased. (Genazzini *et al.,* 2003) the chance of incorporating hospital waste ashes in Portland cement-based materials is presented here. Ash characterization was performed by chemical analysis, X-ray diffraction, radioactive material detection, and fineness and density tests. Al-Rawas *et al.,* (2005) investigated the potential use of incinerator ash as a replacement for sand and cement in cement mortars.The cement, sand and water mixing proportions were 1:3:0.7 respectively. Results showed that incinerator ash caused a reduction in slump values when it was used as a replacement for sand while an opposite trend was observed when it was used as a replacement for cement. (Genazzini *et al.,* 2005) The new cement–ash composite systems have been tested for future applications in building materials. The additions of hospital ash in cement matrices to be potentially used as construction elements. This involved the assessment of the effect of the additions on the physico mechanical properties of the building materials. Anastasiadou *et al.,* (2011) evaluated the mechanical properties of the medical waste incineration bottom ash using different amounts of ordinary Portland cement (OPC) as a binder. Result showed that strength decreased as the percentage of cement loading was reduced. Filipponi *et al.,* (2003) prepared the different mixes by blending hospital waste incinerator bottom ash with ordinary Portland cement in different proportions and at different water dosages. Results at curing times longer than 28 days and for waste dosages higher than 50% suggested that bottom ash exhibited weak pozzolanic property. (Azni *et al.,* 2005) In Germany 50% of the ash produced from incinerated waste is used for the manufacturing of sound insulation walls at National roads, as well as, sub layers on the streets. 60% of the bottom ash is used for the construction of asphalt and as a sub layer of roads in Netherlands. Anastasiadou *et al.,* (2011) studied the cement based stabilization/solidification of fly and bottom ash generated from incinerated hospital waste to reduce the leachability of the heavy metals present in these materials.

III. MATERIALS AND METHODS

In the present investigation and experimental program was carried out to investigate the suitability of use of biomedical waste ash as partial replacement of cement in concrete and effect of replacement of cement of biomedical waste ash on workability of concrete in general and on compressive strength in particular. The properties of materials used in this investigation is discussed here in after-:

A. CEMENT

Portland pozzolana cement is used throughout in the investigation. The physical properties of cement is given in table 1.

.Table 1- Properties of cement (Method of test refers to IS: 4032: 1985)

Properties	**Experimental Value**	**Followed IS specification**
Standard consistency %	31%	IS:4031(4)
Initial setting time	235 minutes	IS:4031(5)
Final setting time	325 minutes	
Soundness (lechatelier expansion)	0.5 mm	IS:4031(3)
Fineness (% retained on 90 µ is seive)	3.50%	IS:4031(1)
7th day Compressive strength	32 MPa	IS:4031(6)
28th day Compressive strength	43 MPa	
Specific gravity	2.71	IS:4031(11)

B. FINE AGGREGATE

Locally available jamuna sand was used in this investigation as fine aggregate. The specific gravity of fine aggregate was 2.30.

Table 2- Result of Sieve Analysis Test for Fine Aggregate (FA)

Fineness Modulus = 275/100 = 2.75. Results of sieve analysis of fine aggregate is given in table 2.

S. No.	**IS Sieve Size**	**Weight Retained (g)**	**Cumulative Weight Retained (g)**	**Cumulative Weight Retained Percentage (g)**	**Cumulative Passing Percentage (FA)**	**Standard Passing Percentage Limits for Zone II**	
						Lower Permissible Limit (UPL)	**Upper Permissible Limit (UPL)**
1	10 mm	0	0	0	100	100	100
2	4.75 mm	50	50	5	95	90	100
3	2.36 mm	58	108	11	89	75	100
4	1.18 mm	170	278	28	72	55	90
5	600 µm	170	448	45	55	35	59
6	300 µm	432	880	88	12	8	30
7	150 µm	100	980	98	2	2	10
8	Pan	20	1000	-	-	-	-
					Total=275		

C. COARSE AGGREGATE

In the present investigation coarse aggregate of 20 and 10 mm nominal size was used.

Table 3 - Result of Recorded sieve analysis test for 20 mm Nominal size coarse aggregate (20mm CA) Fineness Modulus = 701.18/100 = 7.012

S. No.	**IS Sieve Size**	**Weight Retained (g)**	**Cumulative Weight Retained (g)**	**Cumulative Weight Retained Percentage (g)**	**Cumulative Passing Percentage (FA)**	**Standard Passing Percentage Limits for 20 mm Graded Aggregate**	
						Lower Permissible Limit (UPL)	**Upper Permissible Limit (UPL)**
1	25 mm	0	0	0	100	100	100
2	20 mm	64	64	1.28	98.72	95	100
3	10 mm	4932	4996	99.9	0.1	25	55
4	4.75 mm	4	5000	100	0	0	10
5	2.36 mm	0	5000	100	0	-	-
6	1.18 mm	0	5000	100	0	-	-
7	600 µm	0	5000	100	0	-	-
8	300 µm	0	5000	100	0	-	-
9	150 µm	0	5000	100	0	-	-
				Total=701.18			

Table 4 - Result of Recorded sieve analysis test for 10 mm Nominal size coarse aggregate (10mm CA)

S. No.	**IS Sieve Size**	**Weight Retained (g)**	**Cumulative Weight Retained (g)**	**Cumulative Weight Retained Percentage (g)**	**Cumulative Passing Percentage (FA)**	**Standard Passing Percentage Limits for 20 mm Graded Aggregate**	
						Lower Permissible Limit (UPL)	**Upper Permissible Limit (UPL)**
1	25 mm	0	0	0	100	100	100
2	20 mm	0	0	0	100	95	100
3	10 mm	162	162	8.1	92	25	55
4	4.75 mm	3986	4148	87.5	12.5	0	10
5	2.36 mm	852	5000	100	0	-	-
6	1.18 mm	0	5000	100	0	-	-
7	600µm	0	5000	100	0	-	-
8	300µm	0	5000	100	0	-	-
9	150µm	0	5000	100	0	-	-
				Total=595.6			

Fineness Modulus = 595.6/100 = 5.956
Specific gravity of coarse aggregate was 2.6 for both the size. Result of sieve analysis of coarse aggregate for 20 mm and 10 mm are given in table 3 and 4 respectively.

D. Biomedical waste ash

Biomedical waste ash is obtained from Naini, Allahabad incinerator plant. It is grey in colour, coarser than cement but lighter in weight than cement.

E. Super plasticizer (Water Reducer)

Sulphonated naphthalene formaldehyde (SNF) based Superplasticizer (KEM SUPLAST 101 S)of Chembond chemicals was used which conforms to IS:9103-1999 specifications. It was in liquid form compatible with the used Cement, brown in colour having specific gravity 1.2 and It showed good deflocculation and dispersion with cement particles to fluidfy the concrete mix results with enhancement in workability of concrete mix.

F. CONCRETE

The concrete mix design is done in accordance with IS 10262(2009). The cement content used in the mix design is taken as 380 kg/m^3 which satisfies minimum requirement of 300 kg/m^3 in order to avoid the balling effect**.** M-20 grade of concrete conforming to IS: 10262-2009 guidelines was designed as the referral concrete with the mix proportion 1:1.54:3 with water-cement ratio 0.45.

G. WORKABILITY AS SLUMP TEST

Slump test is the most commonly used method of measuring consistency of concrete which is employed in this experimental study. The test was done in accordance with IS 1199 - 1917.

Fig 1 slump test

IV. RESULT AND DISCUSSION

The result of experimental program carried out to determine workability, density and compressive strength are discussed here in after.

A. WORKABILITY

Workability is the property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product.

Result of workability of referral as well as concrete by using biomedical waste ash as partial replacement of cement is given in table 5 and figure 1 for visual observation. It is evident from table that workability of concrete from table that workability of concrete decreased with increase in replacement level. This may be due to the reason that being lighter than cement. Biomedical waste ash occupies more volume than cement on equal weight basis resulting which more water is needed for lubrication thereby decrease in workability resulting.

Table 5 Workability of Concrete at different replacement level of cement

Cube designation	% Replacement of biomedical waste ash	Water cement ratio(cement + biomedical waste ash)	Dose of superplasticizer (%)	Slump (mm)
C1	0	0.45	0.6	110
C2	2.5	0.45	0.6	110
C3	5	0.45	0.6	100
C4	7.5	0.45	0.6	90
C5	10	0.45	0.6	80
C6	12.5	0.45	0.6	70
C7	15	0.45	0.6	60

B. DENSITY

The density of concrete is a measurement of concrete's solidity. The process of mixing concrete can be modified to form a higher or lower density of concrete end product.

Table 6 Density of concrete at different replacement level of cement

Sl. No.	% Replacement Of Biomedical Waste Ash	Density Of Concrete (kg/m3)
1	0	2571
2	2.5	2566
3	5	2560
4	7.5	2554
5	10	2551
6	12.5	2546
7	15	2542

It is evident from table that density of concrete that workability of concrete decreased with increase in replacement level. However, no substantial change in density slightly was observed. Density of referral concrete as well as concrete with biomedical waste ash as partial replacement of cement is shown in table 6.

C. COMPRESSIVE STRENGTH

Compressive strength is the maximum compressive stress that, under a gradually applied load a given solid material can sustain without fracture. Compressive strength is calculated by dividing the maximum load by the cross sectional area of a specimen in a compression test.

It is observed that the Compressive strength of concrete specimens at 7 days and 28 days are increased with replacement level up to 5%, it achieved maximum strength at 5% & shows nearly same strength upto 10% replacement of referral concrete

V. CONCLUSION

From the above study following conclusions are drawn :-
(1) Biomedical waste ash can effectively be used in concrete making.
(2) Workability of concrete made using biomedical waste ash is lower than that of conventional concrete.
(3) Density of concrete decreased slightly with increase in replacement level. However upto 15% replacement level density was about 99% of that of conventional concrete.
(4) Compressive strength of concrete with biomedical waste ash satisfied the requirement of normal concrete.

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